



# Role of MODIS Vegetation Phenology Products in the U.S. ForWarn Early Warning System for Forest Threats

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# Introduction



- U.S. forests occupy ~751 million acres (~1/3 of total land)
- Several abiotic and biotic damage agents disturb, damage, kill, and/or threaten these forests
- Regionally extensive forest disturbances can also threaten human life and property, bio-diversity and water supplies
- Timely regional forest disturbance monitoring products are needed to aid forest health management work at finer scales
- Daily MODIS data provide a means to monitor regional forest disturbances on a weekly basis, leveraging vegetation phenology
- In response, the USFS and NASA began collaborating in 2006 to develop a Near Real Time (NRT) forest monitoring capability, based on MODIS NDVI data, as part of a national forest threat Early Warning System (EWS)

# U.S. ForWarn System for Regional Forest Disturbance Monitoring

Stennis Space Center



<http://forwarn.forestthreats.org>

The screenshot shows the ForWarn website interface. At the top, there's a navigation bar with links: Home, Overview, News, Highlights, Data, and Support. The main header features the ForWarn logo and the tagline "Satellite-Based Change Recognition and Tracking". To the right of the header are logos for the USDA Forest Service, NASA, USGS, and Oak Ridge National Laboratory. A search bar and a "CONTACT US" link are also present. The main content area displays a large satellite image of a forest with a dark overlay box containing the headline "Tornadoes scar the South". The text below the headline states: "Forests across northern Mississippi, Alabama and Georgia were hard hit by tornadoes in April, 2011. Tree mortality was often severe for areas in the direct path of these storms as shown in this photo from near Lake Burton in the Chattahoochee...". A "read more »" link is provided. Below this, there are two sections: "What is ForWarn?" and "Recent News". The "What is ForWarn?" section describes the system as a satellite-based forest disturbance monitoring system for the conterminous United States, providing new forest change products every eight days and tools for attributing abnormalities to insects, disease, wildfire, storms, human development or unusual weather. It mentions archived data provide disturbance tracking across all lands since 2000 and that interactive maps are accessible via the Forest Change Assessment Viewer. A small map of the United States is shown. The "Recent News" section lists two news items: "Official ForWarn News Release Now Available" dated 03/21/2012 - 09:25, and "Introducing the Pest Proximity Database" dated 02/17/2012 - 10:40. A "more news »" link is at the bottom right. The footer contains various links: USDA Forest Service, EFETAC, WWETAC, Policies and Links, Privacy Policy, Accessibility Statement, FOIA, Non-discrimination Statement, White House, usa.gov, and Log In.

**ForWarn**  
Satellite-Based Change Recognition and Tracking

Home Overview News Highlights Data Support

**Tornadoes scar the South**

Forests across northern Mississippi, Alabama and Georgia were hard hit by tornadoes in April, 2011. Tree mortality was often severe for areas in the direct path of these storms as shown in this photo from near Lake Burton in the Chattahoochee...

[read more »](#)

**What is ForWarn?**

ForWarn is a satellite-based forest disturbance monitoring system for the conterminous United States. It delivers new forest change products every eight days and provides tools for attributing abnormalities to insects, disease, wildfire, storms, human development or unusual weather. Archived data provide disturbance tracking across all lands since 2000. Interactive maps are accessible via the [Forest Change Assessment Viewer](#). Read more about ForWarn [here](#).

**Recent News**

**Official ForWarn News Release Now Available**

03/21/2012 - 09:25 The official news release from the USDA Forest Service and NASA announcing ForWarn is now available for download!  
[USDA FS AND NASA JOINT PRESS RELEASE 03.15.12.DOC](#)

**Introducing the Pest Proximity Database**

02/17/2012 - 10:40 The new Pest Proximity Database, now built into the Forest Change Assessment Viewer, helps determine which insects and disease agents are most likely to have been responsible for new forest...

[more news »](#)

USDA Forest Service EFETAC WWETAC Policies and Links Privacy Policy Accessibility Statement FOIA Non-discrimination Statement White House usa.gov Log In

# What is ForWarn?

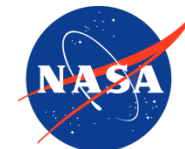


- ForWarn is an on-line geospatial data analysis tool for detecting and tracking regionally evident forest disturbances in the U.S.
- Developed by the US Forest Service in collaboration with NASA, ORNL, and the USGS per mandate of the Healthy Forest Restoration Act
- Uses 250m MODIS satellite NDVI data products to detect changes in vegetation canopy greenness that are anomalous in terms of normal phenology
- Includes a suite of annual MODIS NDVI phenology products and near real time forest change products derived from these products

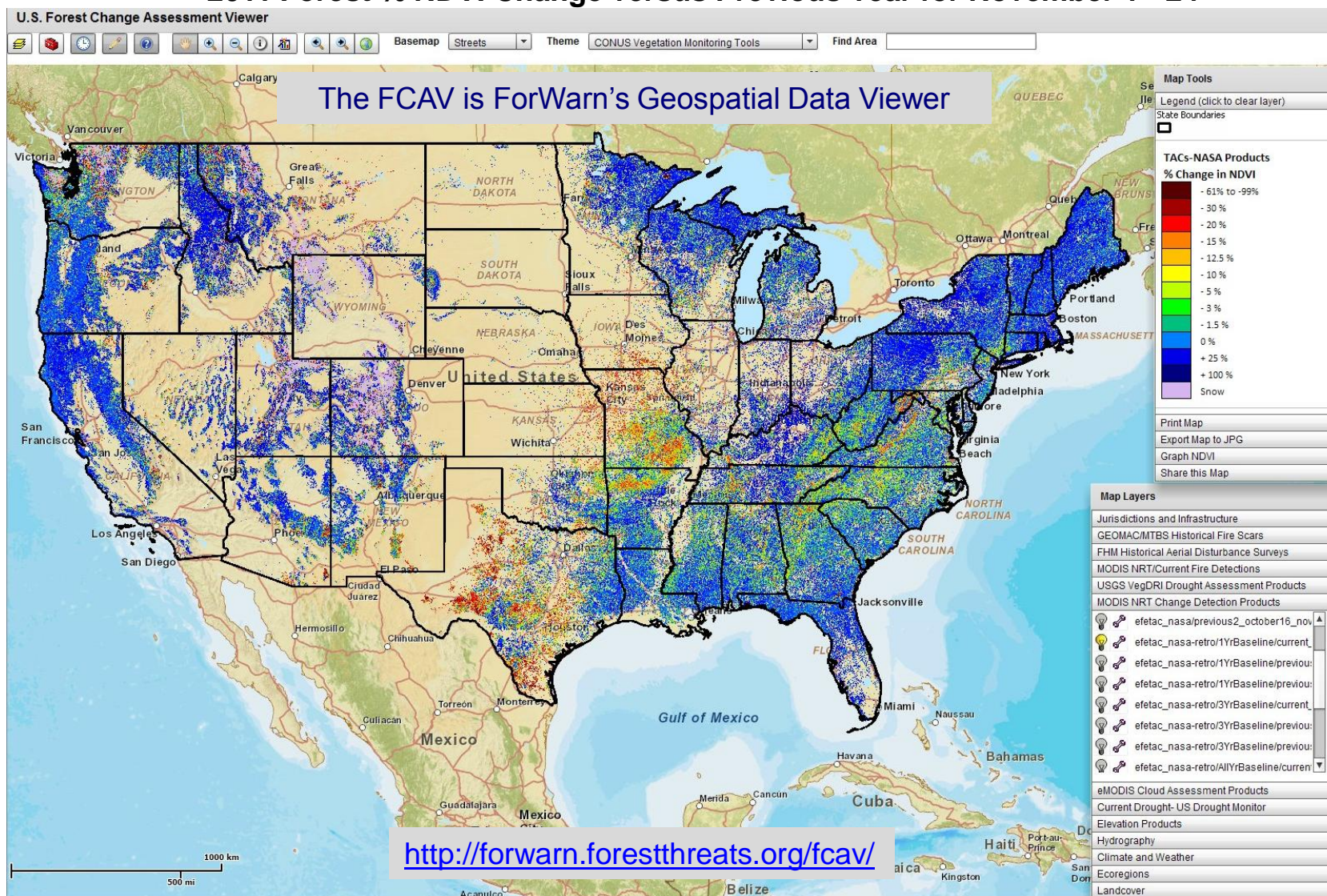


# U.S Forest Change Assessment Viewer (FCAV) - New Products Every 8 Days

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2011 Forest % NDVI Change versus Previous Year for November 1 - 24



# Process for Computing ForWarn MODIS NDVI Phenology Products

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**Input MOD13 Maximum Value NDVI Products**  
Preprocessed with Time Series Product Tool (TSPT)

## *Processing with Phenological Parameters Estimation Tool (PPET)*

Identify the  
Growing Season

Locate Seasonal  
Transition Points

Identify Seasonal  
Values and Dates

Calculate Seasonal  
and Cumulative  
Integrals

**Output Phenology Products**

### **Phenology Parameters (NDVI and DOY for 7 Key Points)**

Left Minima  
Left 20% of Seasonal Maximum  
Left 80% of Seasonal Maximum  
Seasonal Maximum  
Right 80% of Seasonal Maximum  
Right 20% of Seasonal Maximum  
Right Minima

### **NDVI Integral Products**

Small Integral of Growing Season NDVI  
Large Integral of Growing Season NDVI  
46 Cumulative Integral NDVIs per Year

Compute 24 Day  
Historical NDVI  
Baselines

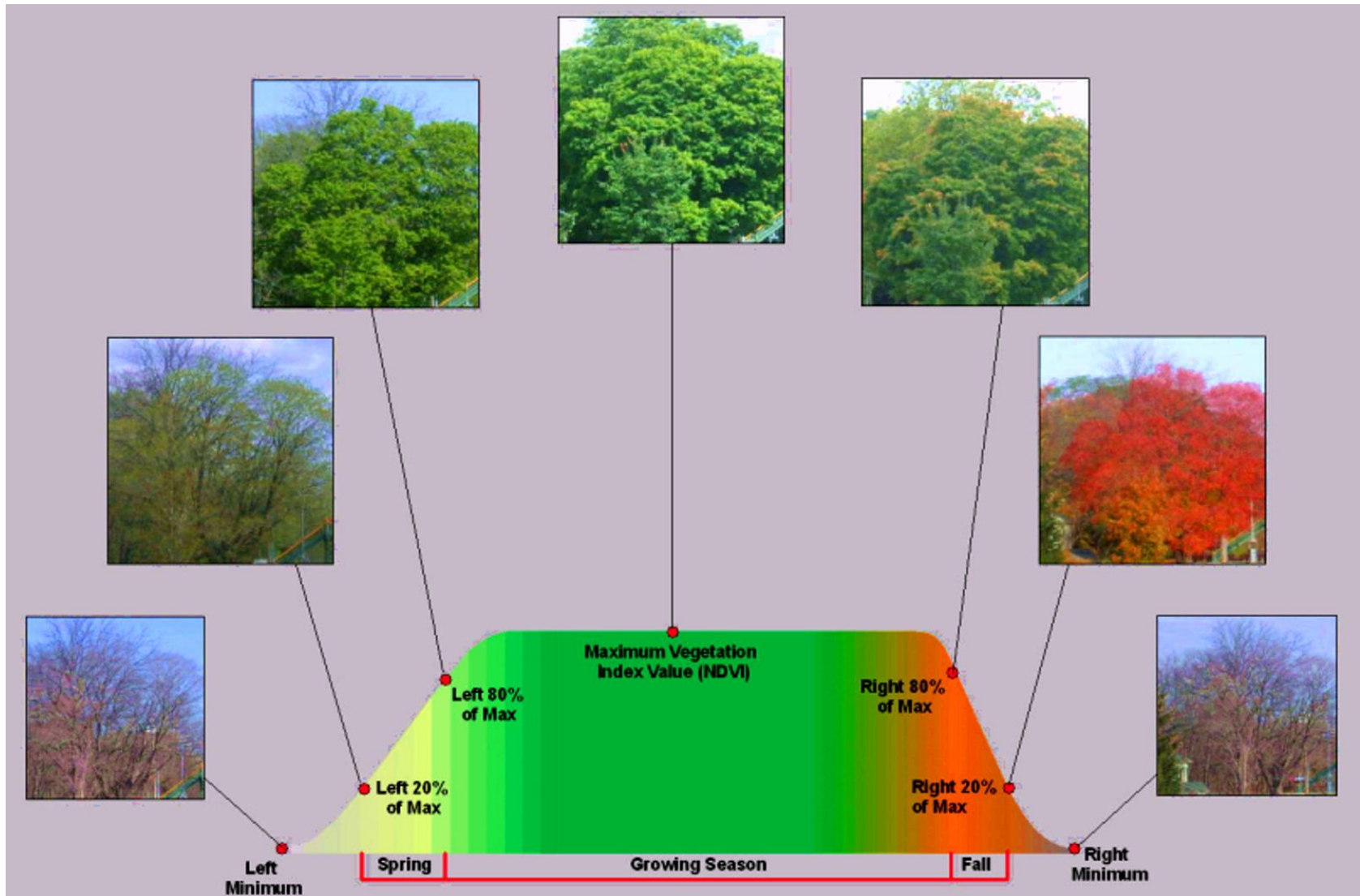
Compute 24 Day  
eMODIS NDVIs

**% NDVI Change Products**  
Change vs. Previous Year  
Change vs. 3 Previous Years  
Change vs. All Previous Years



# Seasonal States of Individual Tree Compared to Phenology Parameters

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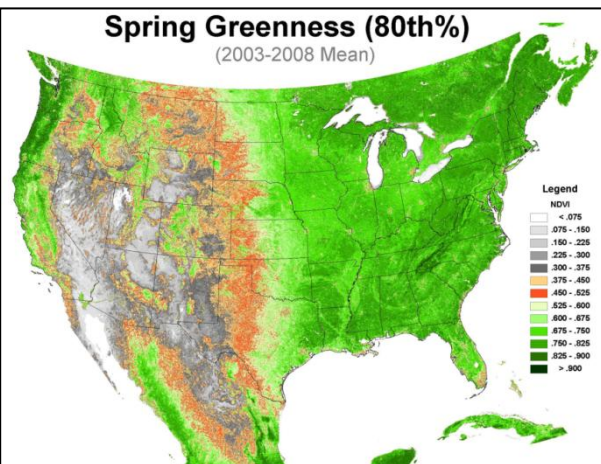
# Example MODIS Phenology Products



## CONUS Historical NDVI Phenology Products for 2000 – 2011

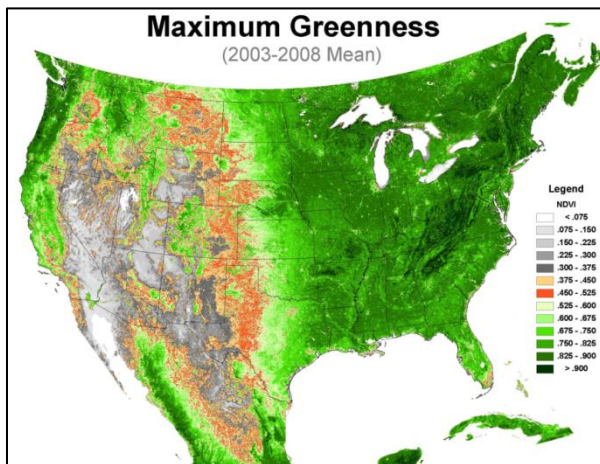
**Spring Greenness (80th%)**

(2003-2008 Mean)



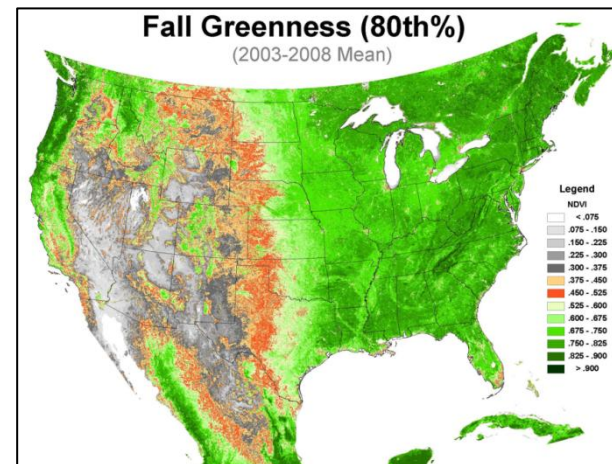
**Maximum Greenness**

(2003-2008 Mean)



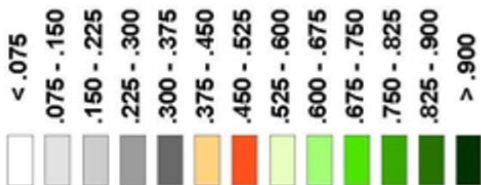
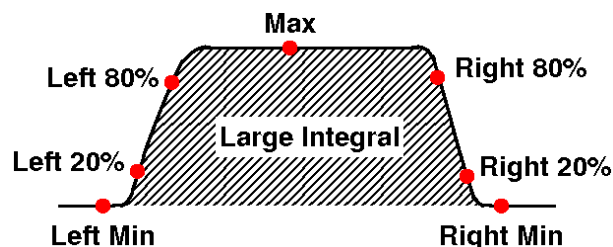
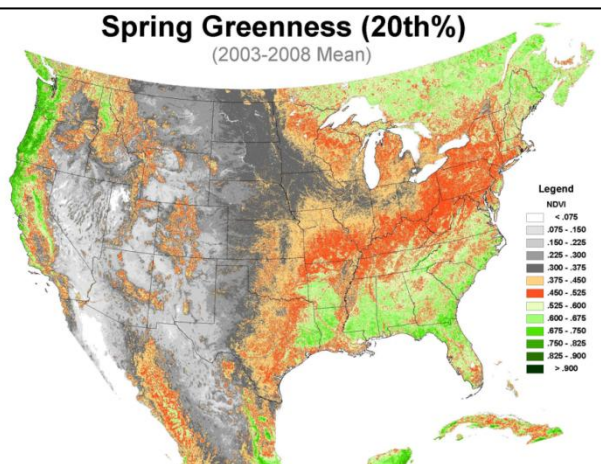
**Fall Greenness (80th%)**

(2003-2008 Mean)



**Spring Greenness (20th%)**

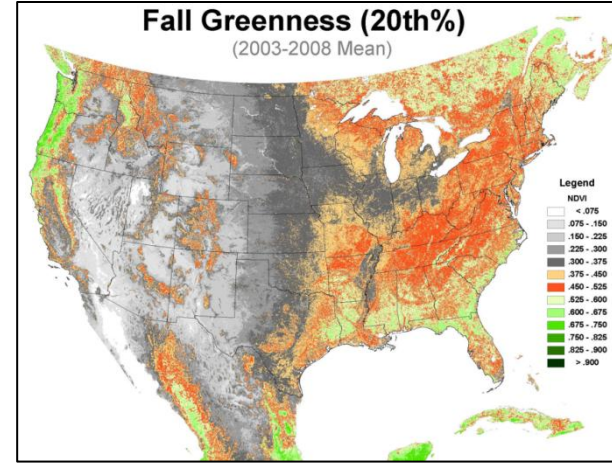
(2003-2008 Mean)



Positive NDVI s Scaled from 0.0 to 1.00

**Fall Greenness (20th%)**

(2003-2008 Mean)





# Series 1 – Examples of ForWarn MODIS Change Products With Regionally Evident Abiotic Forest Disturbances

*2011 Tornadoes  
in Alabama and Mississippi*



Source: NOAA

*2012 High Park Fire in  
Colorado Front Range*



Source: NASA

*2012 Hail Damage  
Asheville Watershed, NC*



Source: USFS

*2011 Drought in Texas,  
and Adjacent States*



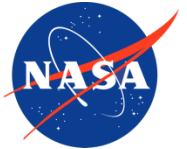
Source: NOAA



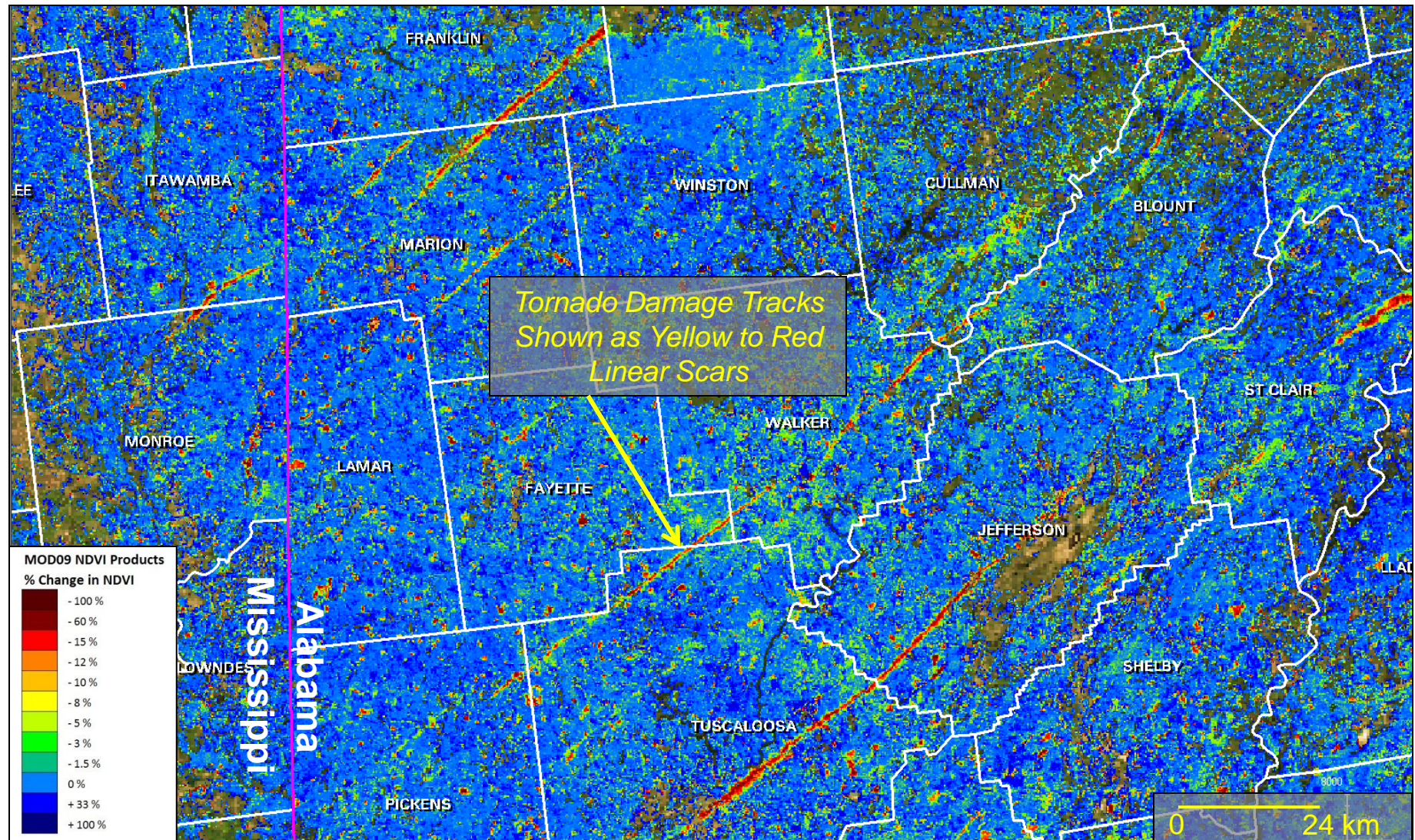
# MODIS View of April 27, 2011

## Tornadoes in Mississippi and Alabama

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Forest %NDVI Change for May 1-24, 2011 versus 2010 – Counties in White



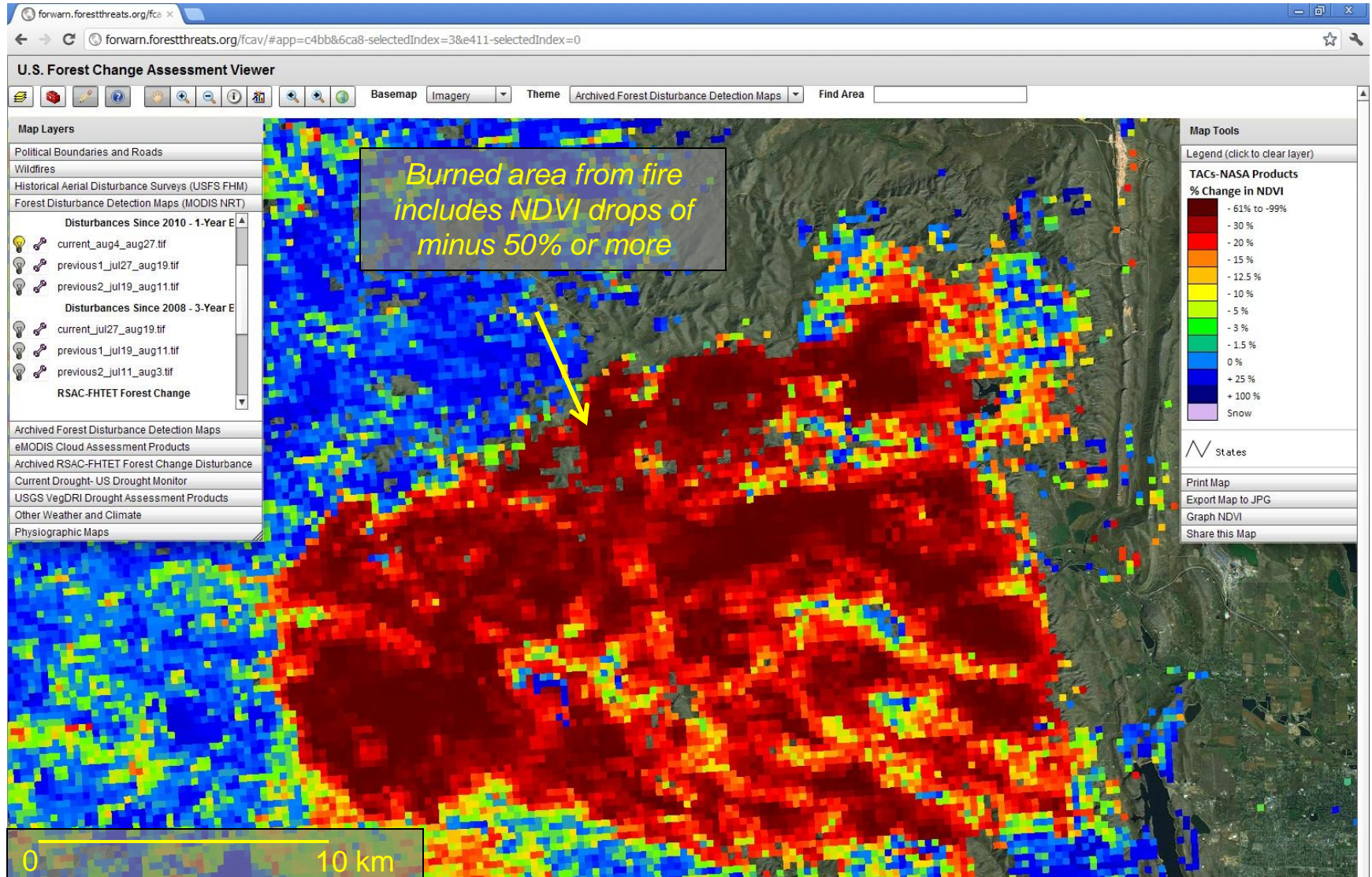


# MODIS View of 2012 High Park Fire in Colorado Front Range

Stennis Space Center



*Forest % NDVI Change for August 4 – 27, 2012 versus 2011*





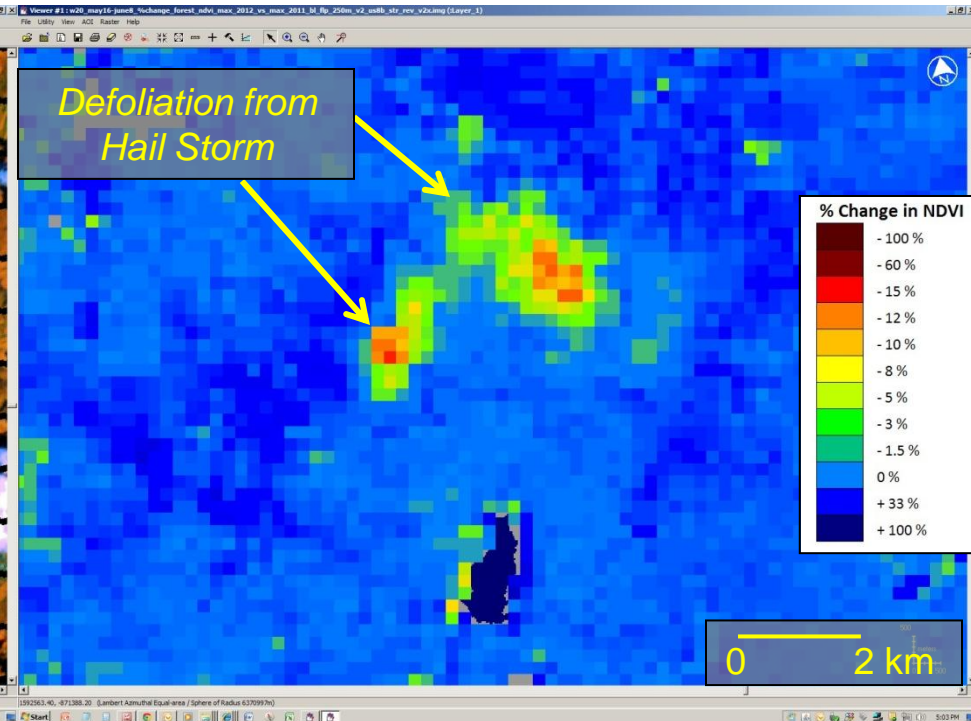
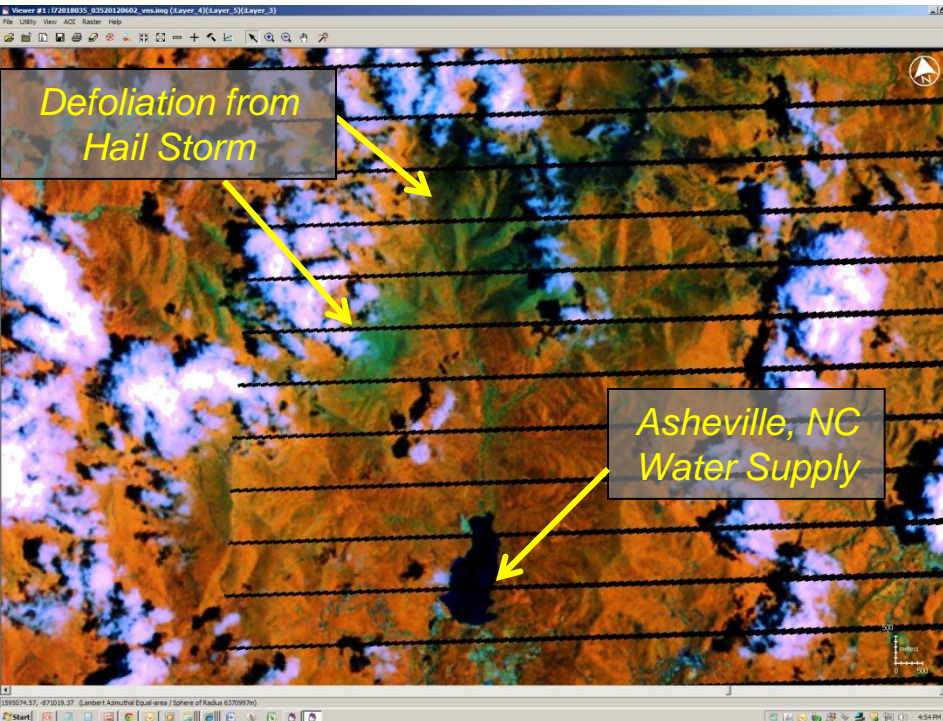
# MODIS View of 2012 Hail Damage to Asheville, North Carolina Watershed

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*Landsat 7 False Color RGB from 6/2/2012*

*MODIS % NDVI Change for 5/16 to 6/8/2012 vs. 2011*



*Area Field Checked 6/14/2012*

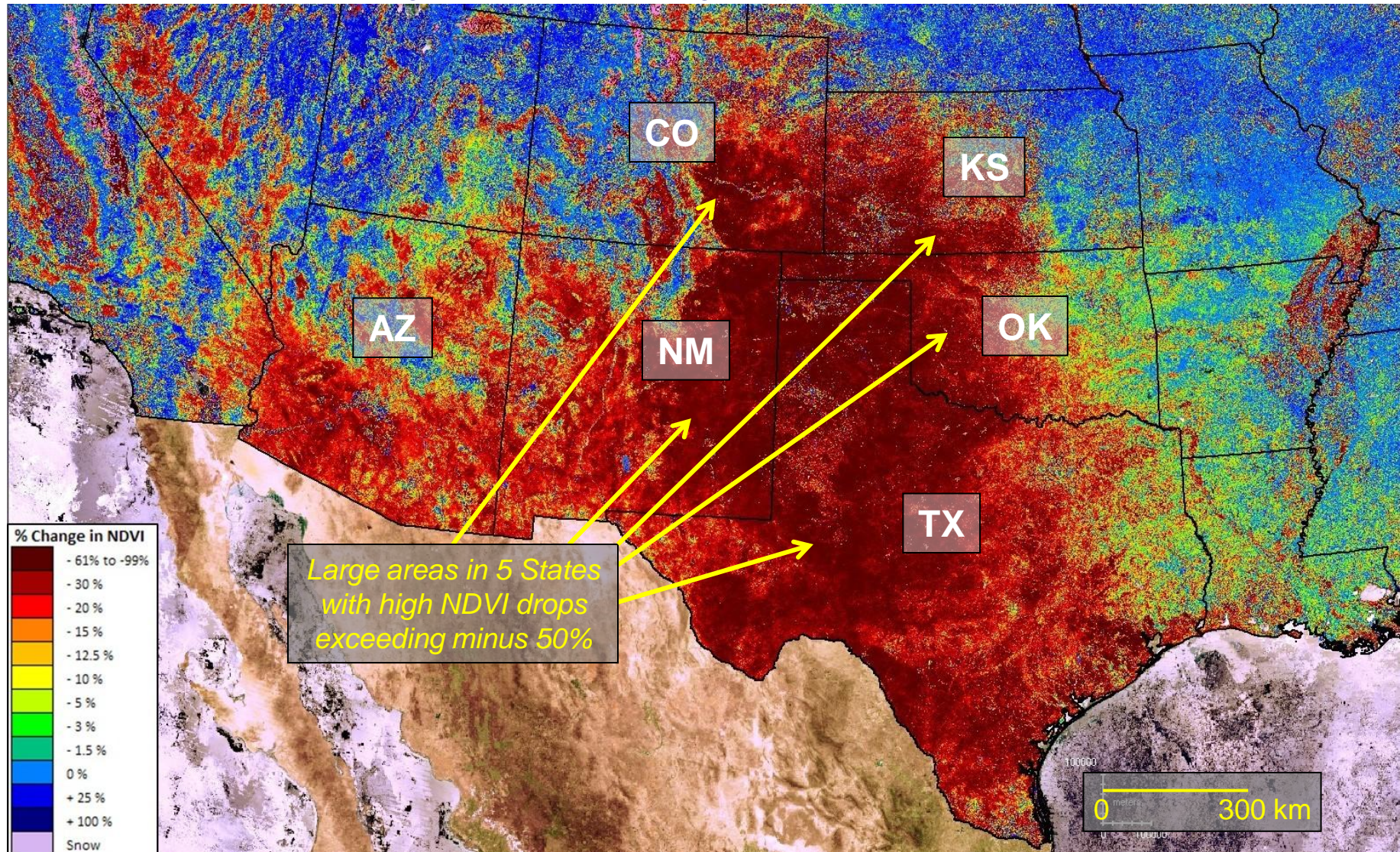


# MODIS View of 2011 Drought in Southeastern U.S.



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*Land %NDVI Change for June 18 through July 11 of 2011 versus 2003-2010*





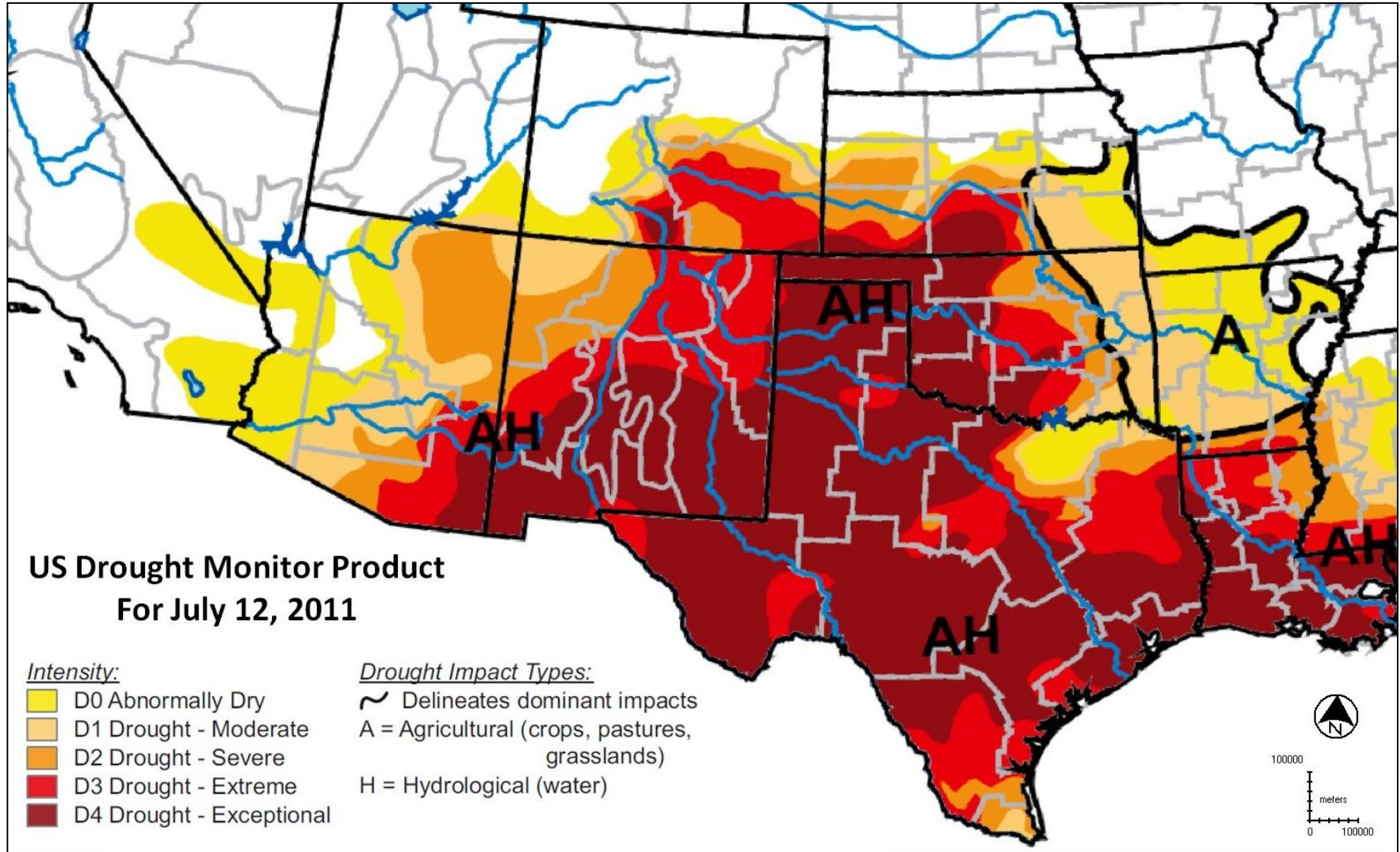
# U.S. Drought Monitor View of 2011

## Drought in Texas and Adjacent States

Stennis Space Center



*U.S. Drought Monitor Product for July 12, 2011*





## Series 2 – Examples of ForWarn MODIS Change Products Showing Regionally Evident Biotic Forest Disturbances

*2012 Spring Defoliation in Louisiana Swamps from Caterpillars*



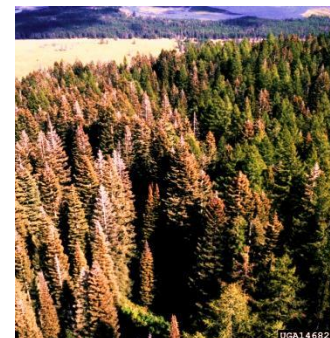
Source: LSU

*2012 Summer Spruce Beetle Mortality in Rio Grande NF of Colorado*



Source: CSU

*2011 Summer Budworm Defoliation in Washington State*



Source: USFS

*2011 Fall Defoliation in Pennsylvania From Fall Webworm*



Source: Texas FS

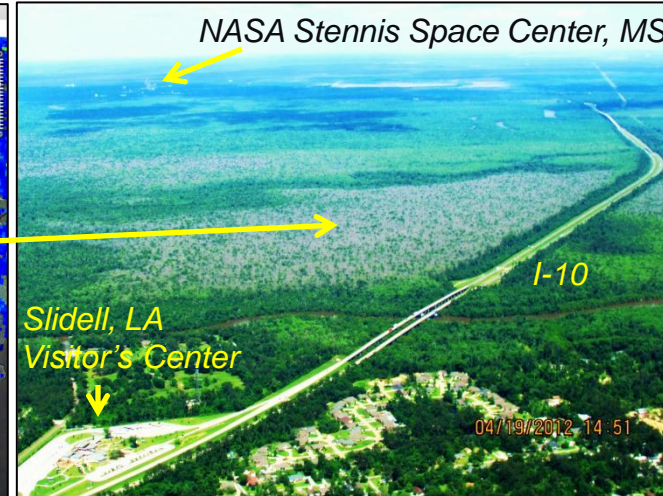
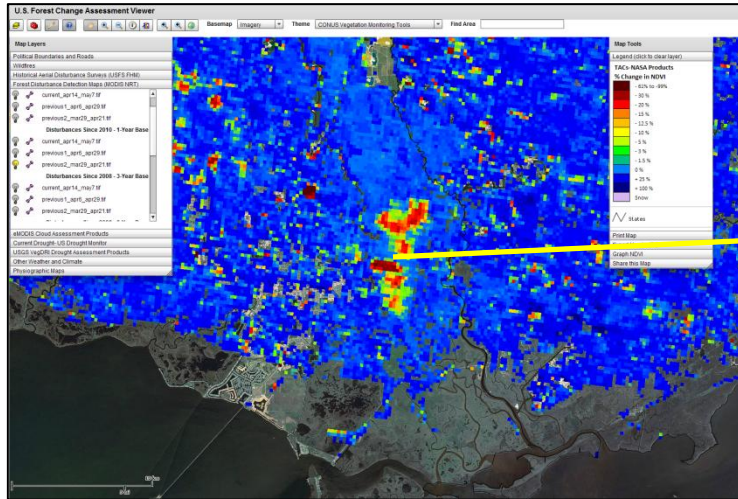
# MODIS View of 2012 Wetland Forest Defoliation in Coastal Louisiana

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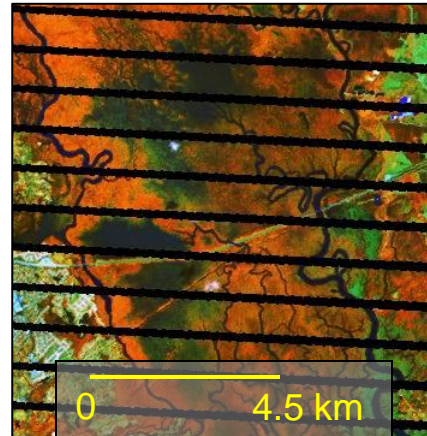
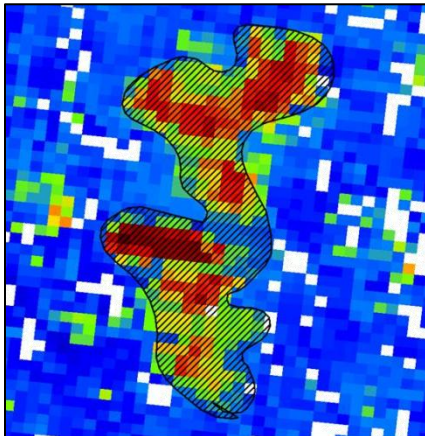
*MODIS Forest % NDVI Change Product  
(Date Ending 4/21 for 2012 versus 2011)*

*Aerial Oblique Below Acquired by DAF  
(Days After Initial ForWarn Notification)*



*2012 MODIS Product with LDAF 2012  
Aerial Survey Polygon from 4/19/2012*

*Landsat False Color RGB Image from  
4/12/2012 (Healthy Forest Orange/Brown)*



*MODIS products showing locations of insect  
defoliated swamp forests – were used to aid aerial  
detection surveys by LDAF and the USFS*



*Above: Pearl River, LA photos of forest tent caterpillar and  
related tree defoliation acquired by NASA*

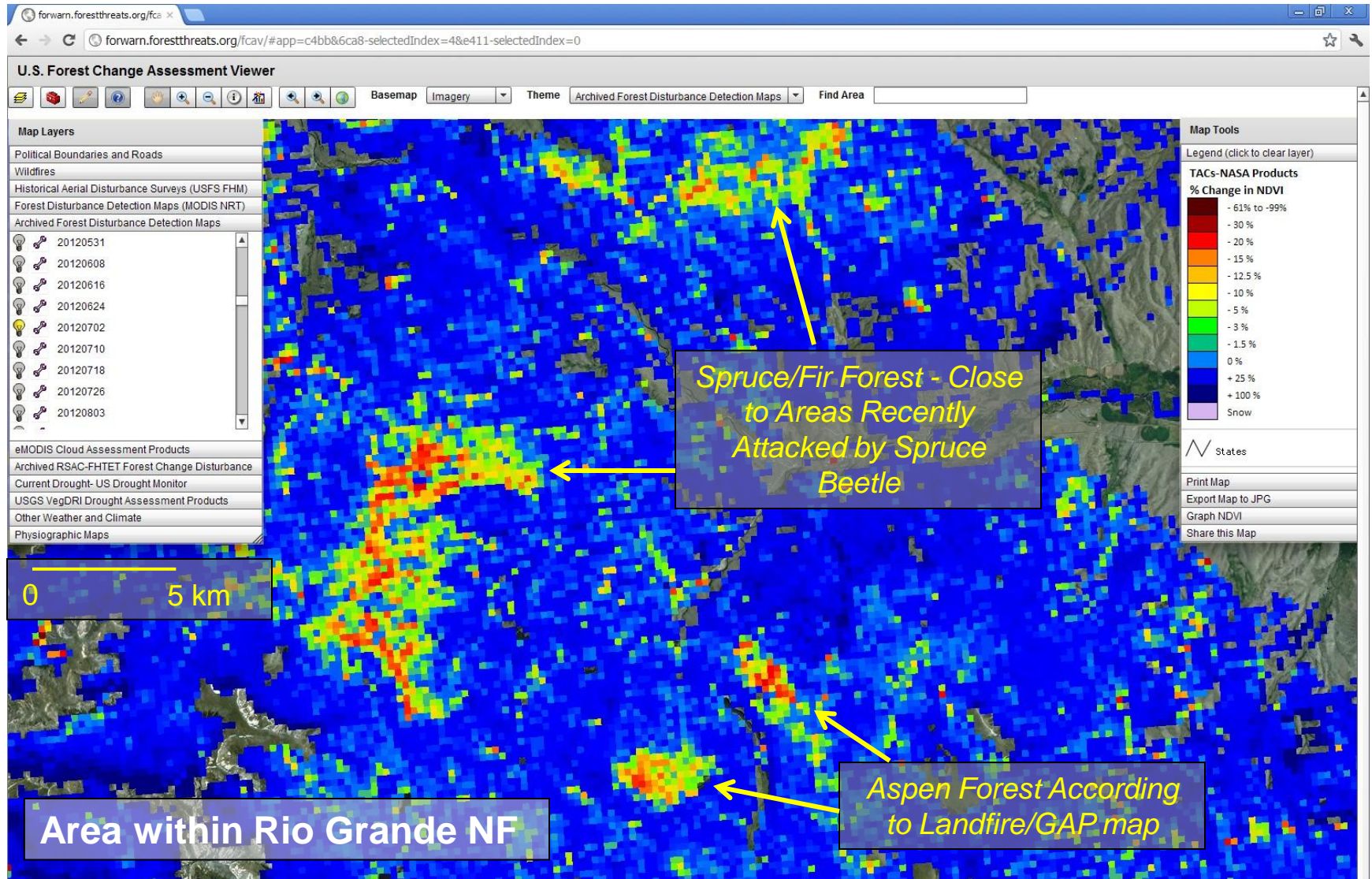


# MODIS View of Potential New 2012 Spruce Beetle Mortality in Colorado

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*Forest % NDVI Change for Date Ending July 2 of 2012 versus 2011*

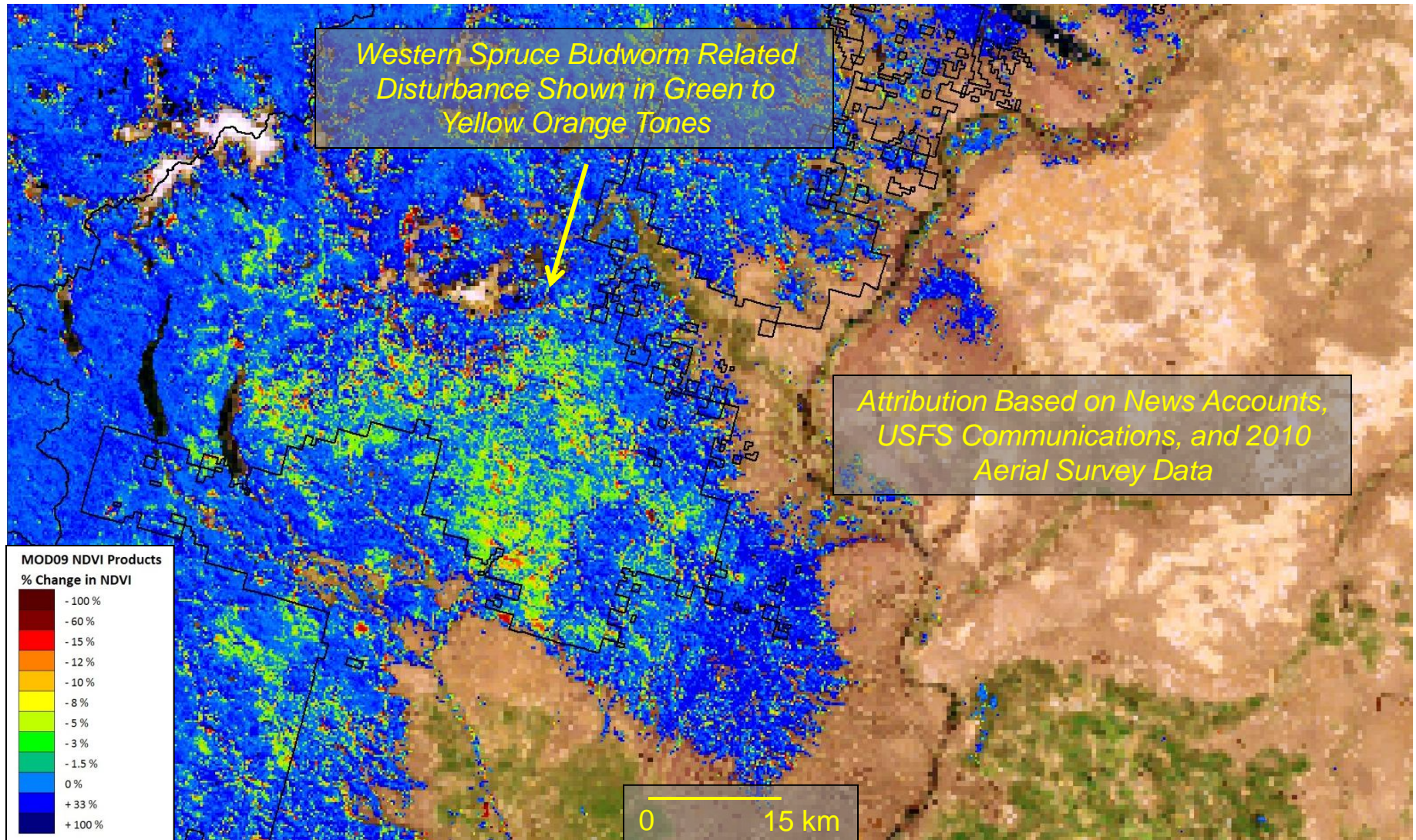




# 2011 MODIS View of Spruce Budworm Defoliation Area in Washington

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Forest %NDVI Change for 8/21 through 9/13 of 2011 versus 2008-2010 – National Forests in Black



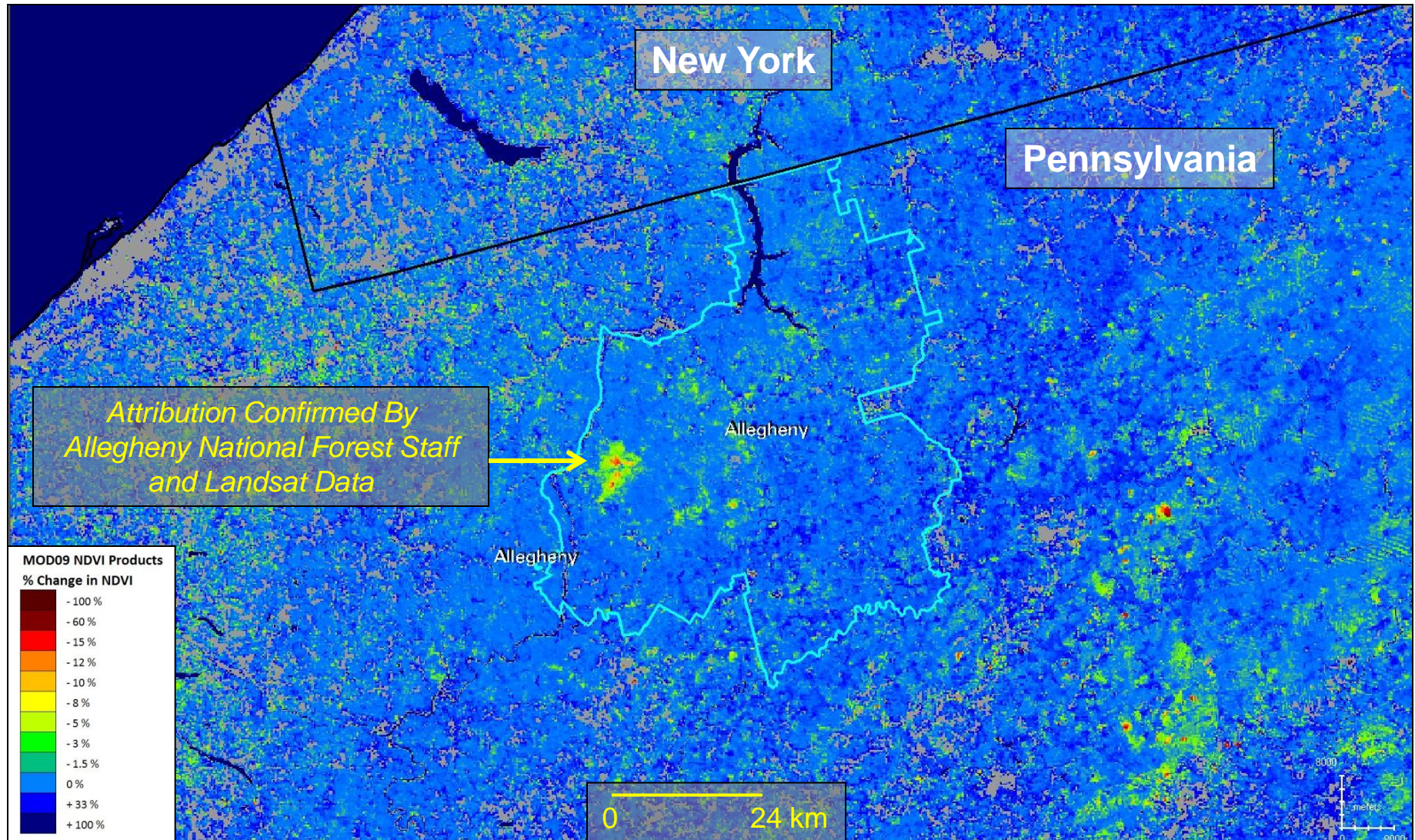


# MODIS View of 2011 Fall Webworm Defoliation in Pennsylvania



Stennis Space Center

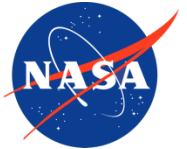
Forest %NDVI Change for 8/21 through 9/13 of 2011 versus 2010 – National Forests in Cyan



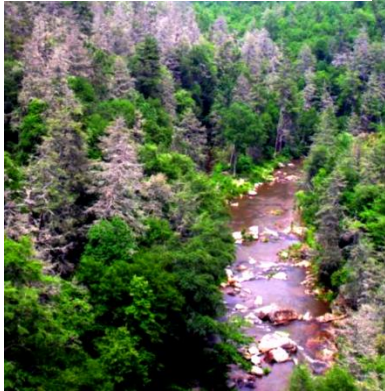


# ForWarn NDVI Profile of Hemlock Woolly Adelgid Forest Mortality Area

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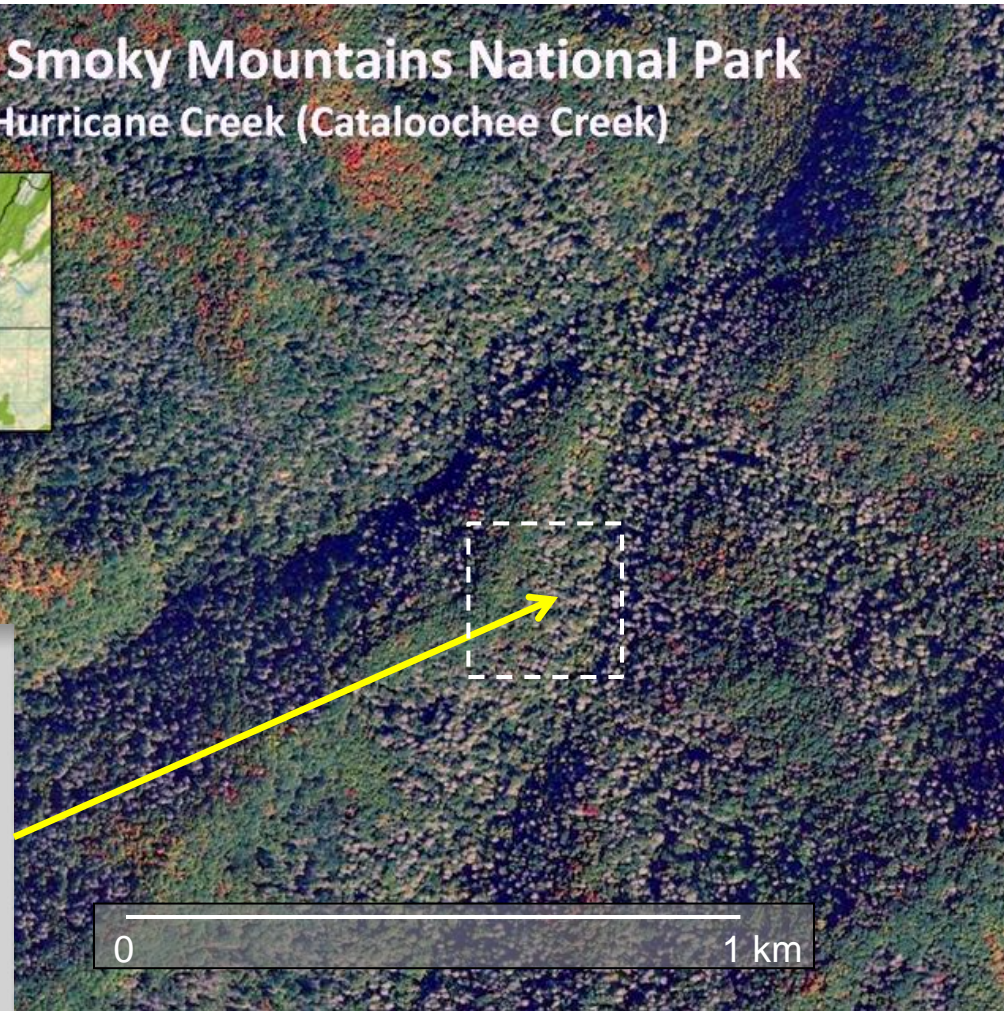


*Oblique View of Hemlock Mortality*

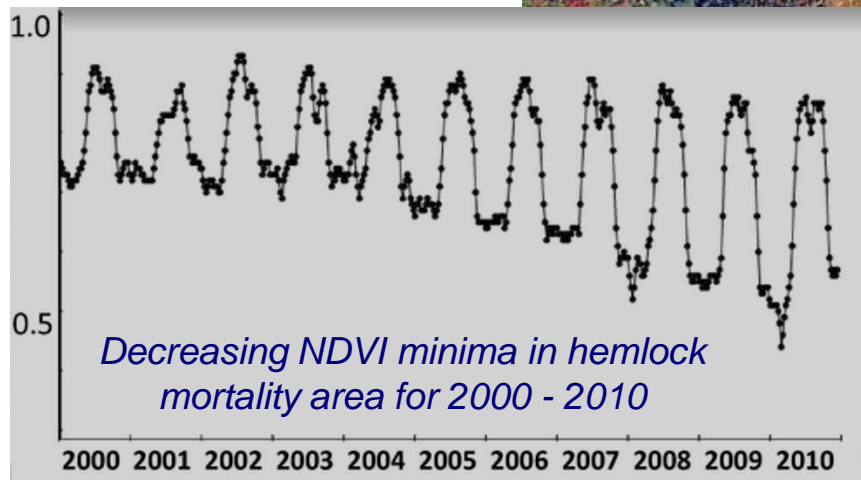


Source: USFS

**Great Smoky Mountains National Park**  
Hurricane Creek (Cataloochee Creek)



*Above – NAIP Aerial True Color Image*





# Comments on Example Results for 2011-2012



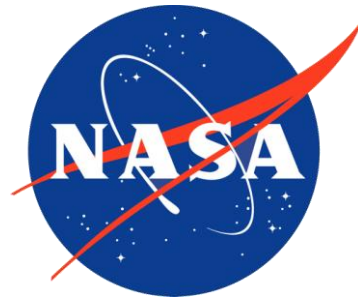
- NRT MODIS CONUS forest change products showed multiple regional forest disturbances
  - *Including abiotic, biotic, and anthropogenic disturbances in softwood, hardwood, and mixed wood forests*
  - *New disturbances were best detected using the previous year NDVI as the baseline*
  - *Multiyear disturbance events were best assessed using all three historical NDVI baselines (previous 1, 3 and all years)*
- Detected disturbances were assessed with news accounts, aerial disturbance survey, fire, and Landsat data
- ForWarn disturbance detection results were conveyed to Federal and State forest health monitoring community

# Conclusions



- Since 2010, NRT MODIS % NDVI change products have been produced for the U.S. every 8 days, usually posted on ForWarn 1-2 days after the last collection date
- ForWarn disturbance detection success requires use of daily MODIS satellite-based phenology data
- Future work
  - *Improving change product freshness and data quality*
  - *More retrospective forest change products*
  - *More product validation studies*
- For more information, email [joseph.p.spruce@nasa.gov](mailto:joseph.p.spruce@nasa.gov)
- Visit the ForWarn web site at: <http://forwarn.forestthreats.org>





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